Ground Related Risk to Transportation Infrastructure

M3 Case Study - Impact of aggressive ground conditions on corrugated steel highways drainage assets

AECOM – Ground Engineering

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The Geological Society

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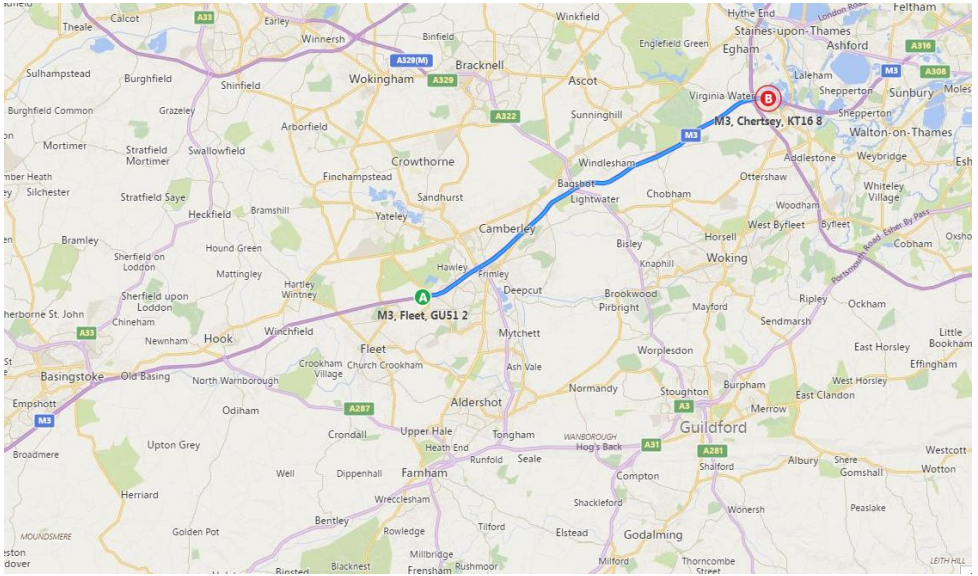
M3 Introduction

- Constructed between 1971 - 1974
- 2014 to 2017 Highways England major project to convert motorway to SMART highway
- Project located between Junction 2 and 4a
- Junction 2 is major interchange with M25



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Project Team

M3 Smart Motorway J2 to 4A

Client : highways england

Principal Contractor: Balfour Beatty

Designer: AECOM

M3 Drainage

- SMART motorway CCTV condition surveys
- Corrugated steel carrier pipes – approximately 4.5km but in discontinuous lengths
- Predominantly located under hard shoulder
- Pipe diameter varies from 450mm to 1100mm
- Depth to pipe crown: between 0.6m and 2.5m below top of pavement
- Estimated pipe thickness: 5mm to 6mm [although in areas of corrosion it may be reduced]

M3 Drainage

- Corroded especially at water line
- Silt and sand has migrated into the pipes where corroded
- Voids discovered adjacent to pipe associated with areas of corrosion

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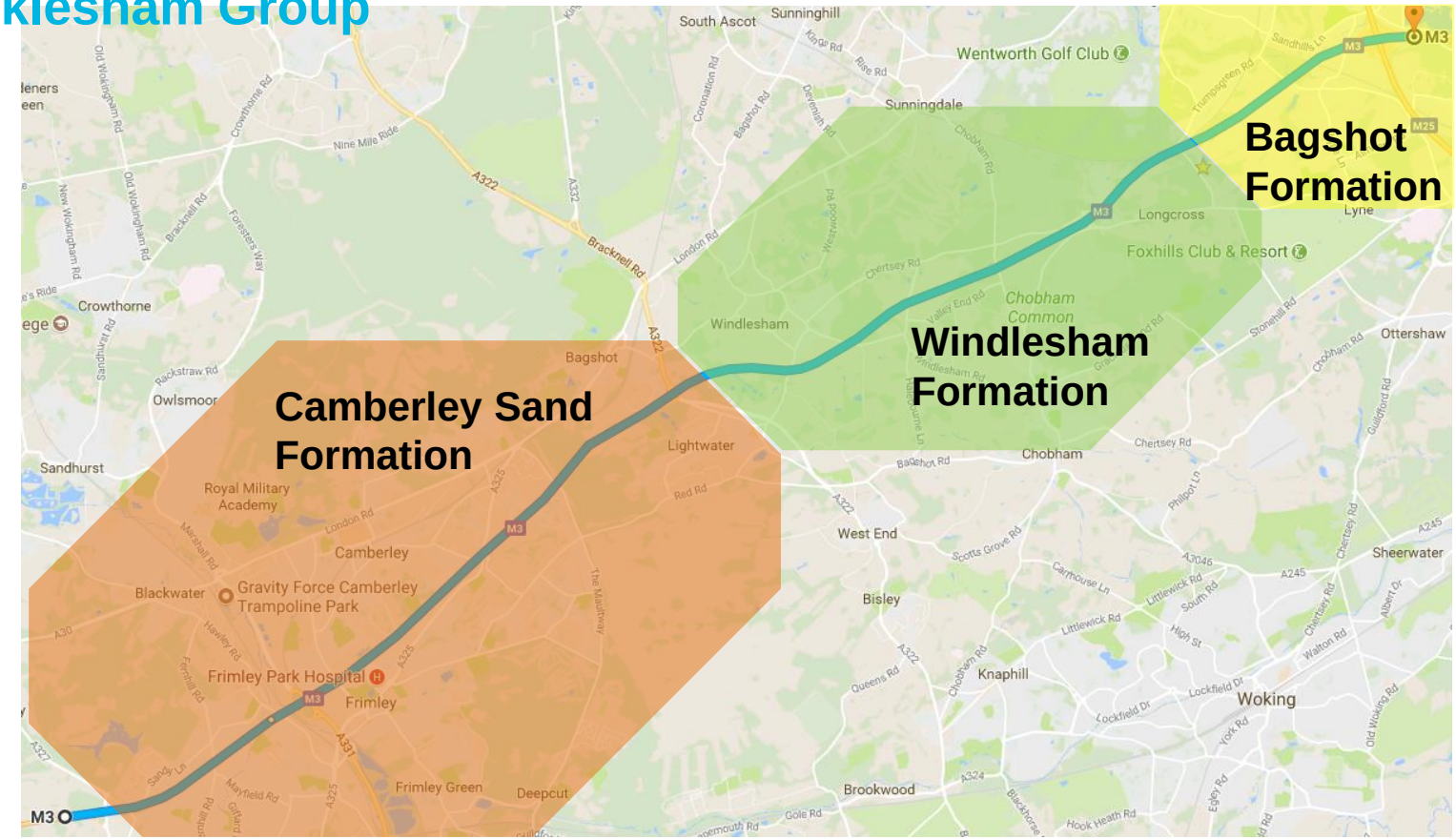
Geological Conditions

Bracklesham Group



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Geological Conditions

Deposits are predominantly comprised of interbedded to interlaminated clays, silts and mostly fine or medium-grained sands, locally shelly.

Glauconite occurs in the mid part of the sequence.

Aggressive Ground Assessment

Geotechnical Design Report (GDR) assessment of pH and sulphate

All values given are Characteristic Values.

Numbers of tests in brackets

Formation	pH	Sulphate (2:1 extract) (mg/l SO_4)	Sulphate (groundwater) (mg/l SO_4)
Bagshot Beds	4.3 (53)	536 (18)	406 (28)
Windlesham Formation	3.9 (65)	470 (2)	813 (49)
Camberley Sands	6.5 (51)	720 (6)	481 (28)

Aggressive Ground Assessment

BD 12/01 Design of Corrugated Steel Buried Structures:

Corrosivity Classification

Score of -5 or less = Very aggressive conditions

- pH <5: -4 points
- Water-soluble sulphate > 240 but ≤ 600 mg/l : –1 point
- Chloride ion presence would also add negative points

Specification for Highway Works series 600 states that:

Material should not be deposited within 500mm of metallic structural elements forming part of the permanent works where water-soluble sulphate exceeds 300mg/l (as SO_4)

Conclusion: Ground at site very aggressive to steel

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Other causes of pipe corrosion

– Road salt

– Pipe age – potentially about 40 years

[Missouri Department of Transportation (Organisational Results Research Report OR08.014, January 2008) indicates that average life expectancy is around 40 years]

Strong relationships with Client and Principal Contractor

- Survey and remedial work undertaken either at night or under traffic management
- Ensure public safety at all times

Ground Penetrating Radar Survey

- Location of the corrugated steel pipes mapped from historical data and CCTV surveys
- GPR surveys undertaken by AECOM's geophysics staff
- Due to live motorway survey work primarily undertaken at night

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GPR survey

Three phases:

1) An initial vehicle mounted reconnaissance level survey
2) First phase of detailed investigations conducted across three areas
3) Second phase of detailed investigations conducted along c. 4km of corrugated steel carrier drain located under the hard shoulder and a number of pipe crossings under the carriageway. This was undertaken during a number of survey sessions.

GPR survey

The second more extensive phase of the detailed investigations was carried out using:

– Cart mounted GSSI dual frequency system comprising 300MHz and 800MHz antennas.

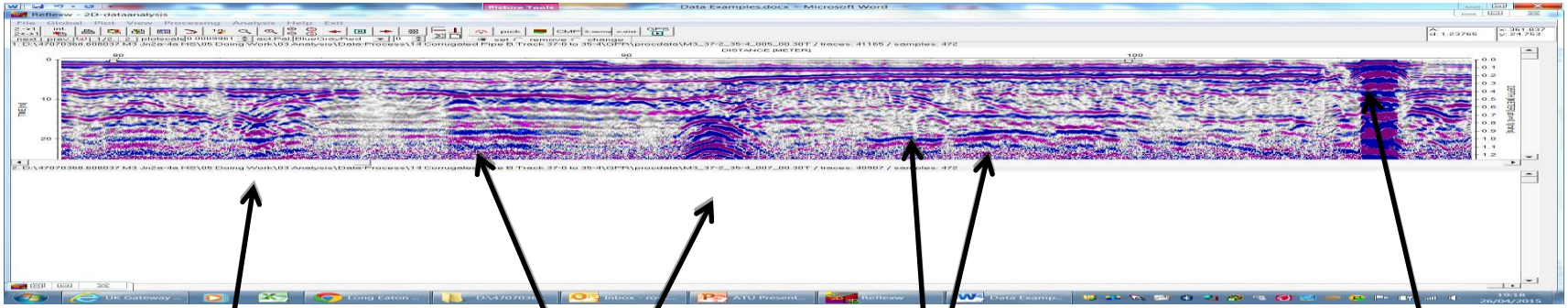
– A series of longitudinal and transverse profiles were collected in a grid pattern with longitudinal profiles collected at a maximum spacing of 0.5m.

– In addition, survey grade GPS equipment was used to record key features of the grid and local fixed points such as inspection covers and marker posts.

– The data from this survey was georeferenced by integrating the radar and topographical data during processing.

Geophysical Assessment Methods

Ground Penetrating Radar (GPR): A typical 2D GPR profile



Construction change / possible service or void

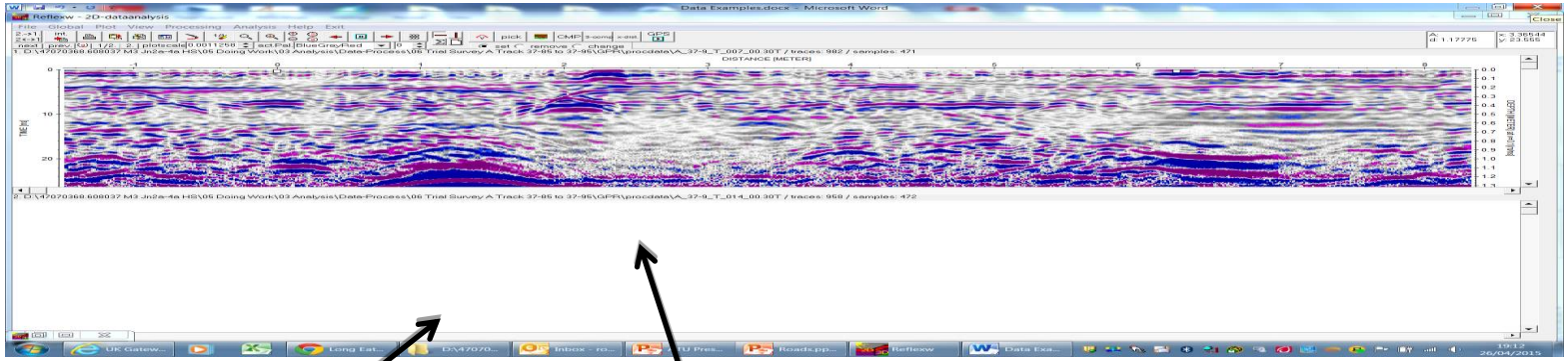
Possible service or void

Striations

Inspection Cover

Geophysical Assessment Methods

Ground Penetrating Radar (GPR): Carrier pipe in good condition



Carrier pipe

Concrete backfill / possible saturated materials

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Intrusive follow up to GPR survey

Geophysical anomalies categorised by response type.

Then ranked as:

- Primary Target - High severity
- Secondary Target - Low severity

No.	Core	Easting	Northing	Core Carried ou
1	Y	500589.72	167277.89	y
2	Y	500472.57	167177.70	y
3	Y	499791.05	166679.73	y
4	Y	499436.00	166472.90	y
5	Y	499413.47	166462.41	y
6	Y	499414.62	166459.88	
7	Y	499381.80	166444.30	y
8	Y	499373.04	166440.04	y
9	Y	499097.41	166268.92	
10	Y	499086.24	166263.07	y
11	Y	498538.49	165984.51	
12	Y	498541.45	165981.22	y

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Intrusive follow up to GPR survey

Geophysical anomalies were investigated by:

– Pavement coring

– TRL probes to defect level

– Endoscope camera work where voids were encountered

Outcome of GPR survey

– Two large voids encountered under hardshoulder and immediately infilled. Pipe length replaced.

– Small voids infilled with concrete

– Confidence that treatment of carrier pipe in-situ was adequate solution for majority of 4.5km

The Finished project

Corrugated steel pipe left in place as former for remedial lining

Remedial liner consisted of a UV-cured Polyester Resin sock

Benefits:

– Removed need for dig out and replace

– Maintained shape and capacity of existing system

– Adequate strength of renewed pipe

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Thank You